

a. m. on that date reveals the actual conditions as existed in the western part of the United States.

Figure 2 shows the tracings from the thermograph, corrected to the thermometer readings, and from the barograph here, from 8 a. m. (seventy-fifth meridian time), October 26 to 8 p. m., October 28, 1918.

The norther, given as an example, came in the early part of the night, but the greater part of them come from 2 to 4 a. m. However, the phenomena preceding this one is typical and the description of the weather preceding a typical norther in this vicinity can be expressed in the following general terms:

There is a very low air pressure during the afternoon before (usually about 29.60 inches) after which it begins to rise gradually until the norther begins to blow, there is a high maximum temperature, high relative humidity, very often a heavy dew in the first part of the night, at times a fog on the morning before, the wind backs from south to northeast and lightning is generally to be seen in the northwest. The first part of the blow is usually accompanied by a light rainfall and there is a

general cloudiness throughout the entire time the norther blows.

The northers are not always typical, but at times blow up when there has been no warning by the air pressure and the other phenomena, as given in the example, and very often they repeat within a few hours' time.

It can be seen that the only method that can be used in making a forecast of a norther in this vicinity is from a comparison of the conditions at any time with those which occurred before a typical norther came, and if the conditions are similar the probability of a norther is very good, as I have found.

The writer feels that until some better means of knowing the coming weather can be provided for Tampico and the east coast of Mexico, our efforts are not in vain. On several occasions light craft have been held in the port by being warned that a norther was very likely to blow within the next 24 hours. The captain of the port of Tampico, wired our daily reports to Vera Cruz during the winter months and words of appreciation have been received from that important port.

FOG IN CENTRAL OHIO AND ITS RELATION TO SUBSEQUENT WEATHER CHANGES.

By HOWARD H. MARTIN, Observer.

[Dated Weather Bureau Office, Columbus, Ohio, May 26, 1919.]

Fog is a meteorological phenomenon. It is the direct result of the depression of the air temperature to a point equal to or lower than the existing dew point. This depression may be brought about by radiation and conduction, cooling by atmospheric expansion, or by the mixing of cold and warm, humid air. Fogs due to radiation occur for the most part over valleys and low ground after a warm afternoon. Those due to cooling by expansion are rarely local, but may cover relatively vast areas. Inland fogs due to mixing usually occur at or near the wind-shift line during the passage of a cyclonic area. Such fogs are uncommon in Ohio, and when they do occur, usually precede a rapid and severe drop in temperature.

All fogs may be classified into (1) radiation fogs, those fogs due to radiation in quiet air and (2) advection fogs, those general fogs due to cooling by conduction, radiation, mixing or expansion in horizontally-moving air. Radiation fogs occur for the most part during the late spring and summer months, are very local and without apparent significance. Advection fogs, being due to air movements, often are indicative of weather changes. These fogs occur during the winter and the early spring months, usually with clouds, and precede a marked rise or fall in pressure by from 6 to 30 hours. It is well to discriminate here, though not in the general classification, between the fogs near or in low pressure centers or troughs, and the fogs immediately in the rear of an anticyclone. The former occur practically at the center of the disturbance, during a temporary lull in the wind, and, of course, are dissipated by the colder, drier winds from the west; the latter often occur during the prevalence of high pressure and appear to be the first symptom, if such a term is permissible here, of an immediate decrease in atmospheric pressure. Of 44 dense fogs recorded under these conditions, 38, or 86 per cent, were followed immediately by decreasing pressure (within 12 hours) and 92 per cent, by falling barometer within 24 hours.

The records of the Weather Bureau Office at Columbus (Ohio) show that from 1900-1918, inclusive, 144 dense fogs occurred. Previous to a study of these fogs, the writer had given considerable attention to the relation of fogs to weather changes in northeast Texas, and the results are comparable, bearing out, to a large degree, the significance of the phenomenon in connection with subsequent precipitation.

It has been found that at Columbus, Ohio, during the months of December, January and February, 1900-1918, dense fogs occurred on 76 days, the average duration in each case being 3.8 hours. Of these, 43 per cent occurred during precipitation; 67 per cent preceded rain or snow by 24 hours or less; 83 per cent by 36 hours or less; and 90 per cent by rain or snow within 48 hours. Of the entire number observed during these months, 92 per cent were followed within 24 to 30 hours by a marked pressure change, and of these changes, 69 per cent were falls, 19 per cent increases, 10 per cent falls followed by rises and 2 per cent by rises followed by falls.

During the months of March, April, and May, 22 dense fogs occurred, with an average duration of 2.7 hours, and of these 29 per cent occurred during precipitation, 40 per cent preceded rain or snow by 24 hours or less; 76 per cent within 36 hours, and 80 per cent within 48 hours. Of these 22 fogs, 76 per cent were followed by marked pressure changes within 24 hours, of which 59 per cent were falls, and 41 per cent rises.

During the summer months, the few dense fogs on record, total 5, were all radiation fogs, and hence had no apparent significance with relation to coming changes.

During the months of September, October, and November, 41 dense fogs were recorded, with an average duration of 4.2 hours. Of these, 17 per cent occurred during precipitation, 39 per cent were followed by rain or snow within 24 hours, 53 per cent within 36 hours, and 66 per cent within 48 hours. Of the number recorded, 63 per cent were followed by marked pressure changes, of

which 50 per cent were falls, 35 per cent increases, and 15 per cent falls preceding increases.

Thus, it may be readily seen that, in central Ohio, for the year (June, July, and August, excluded), 50.8 per cent of all observed dense fogs are followed by rain or snow within 24 hours; that 68.7 per cent precede precipitation by 36 hours or less, and that 78.6 per cent are followed by rain or snow within 48 hours.

To reduce these apparent values to the true prognostic values, it is necessary to determine first the frequency with which a class of variable events wholly unrelated to weather would be followed by precipitation within the prescribed number of hours. Since the 48-hour values are by far the higher, these only will be considered. The writer has determined the frequency with which the hour of sunrise has been followed by precipitation, and by application of the simple formula

$$\frac{P-p}{100-p} = V$$

where P is the apparent percentage of verification, p the percentage possible by chance, as determined above, and V the true prognostic value, the apparent 48-hour percentages are reduced to represent the actual prognostic value.

The hour of sunrise in winter was followed by precipitation within 48 hours on 61 per cent of the total number considered; the apparent 48-hour percentage of verification is thereby reduced from 90 per cent to 74 per cent. Sunrise in spring is followed by rain or snow within 48 hours in 60 per cent of the total cases recorded, which reduced the apparent value of verification 80 per cent to 50 per cent. In autumn, precipitation has followed sunrise within 48 hours on 43 per cent of the occasions, thus reducing the apparent verification 66 per cent to 40 per cent. For the year, summer months excluded, rain or snow follows sunrise within 48 hours 55 per cent of all occasions, and the yearly percentage is thus reduced from 79 per cent to 54 per cent. Thus, the occurrence of fog has a true prognostic value.

There appears to be but little relation in central Ohio between the occurrence of dense fog and subsequent temperature changes, since even in the winter months, but 28 per cent of fogs were followed by temperature falls of 10° or more, while rises of similar degree followed 31 per cent. In the Spring, 55 per cent of the observed fogs were followed by a rise in temperature. In this connection, however, it is interesting to note that in northeast Texas the writer found that 82 per cent of advection fogs were followed by marked temperature falls within 24 hours and 88 per cent preceded such falls by 36 hours or less. From this it is apparent that the greater number of fogs in northeast Texas occurred at or near the windshift line of the passing cyclone, whereas in Ohio, the greater number occur before the oncoming storm has made itself otherwise manifest.

It was found in northeast Texas that the direction of the surface wind at the time of fog is an essential factor in determining the actual relation of the fog to ensuing weather. Thus, with light westerly winds, typical anti-

cyclonic conditions, the prognostic value is greatly minimized; with upper clouds from a westerly direction, and with southerly winds, the fog was usually followed by precipitation within 10 hours, while with easterly winds, high pressure, and slowly rising temperature after a sudden fall, precipitation with marked falling pressure occurred within 18 hours. The wind factor is not of so much importance in central Ohio, since the southwest wind usually prevails throughout the winter months. However, it was found that of the 78.6 per cent of fogs followed by precipitation within 48 hours, 92 per cent occurred with southwest winds, 4 per cent with south winds, and 3 per cent with west winds.

The fog has, from time to time, been recognized in adage and proverb as a possible indication of coming weather changes. In Texas, for instance, it is common to hear the saw, "A winter fog will freeze a dog," the dog in question probably being of the Mexican hairless variety, very susceptible to cold. Along the Pacific coast, it is said that three successive foggy mornings bring rain. It has been said that fog forming at night indicates rain; that of the morning, fair weather; that a rising fog promises clear skies, while a settling fog foretells storm. All these have, perhaps, long periods of observation to bear them out, and in many cases are based on sound meteorological laws. Yet, on the whole, it is better to consider the fog only as a physical result of a combination of meteorological conditions, essential to condensation, and favorable to precipitation.

DISCUSSION.

To get the true value of any phenomenon as a prognostic of rain, for example, the percentages should be compared with those obtainable from the use of a phenomenon unrelated to the occurrence of rainfall. For periods of whole days, the time of sunrise may be used, as Mr. Martin did; but it may be worth while to consider a method which may be applied generally. The percentages found from the tabulation of the phenomenon of prognostic value may be compared with the percentages of the total time which occur during rainfall or within dry periods of differing length before the beginning of rainfall, and which, therefore, represent with what frequency rain would follow within a specified period after any occurrence unrelated to the weather.

Supposing we tabulated: (R) the time (in hours) during which rain has fallen; and the numbers of dry periods according to length, say, (A) 0-12, (B) 12-24, (C) 24-36, (D) 36-48, and (E) over 48, hours; and computed the whole time (T) in hours covered by the period investigated. Using the letters indicated to represent the items just mentioned, we could obtain the frequency with which rain would occur within 12, 24, 36, or 48 hours after any instant, by the following formulas:

Probability of rainfall within—

$$12 \text{ hours} = [R + 12 (\frac{1}{2} (A) + B + C + D + E)]/T.$$

$$24 \text{ hours} = [R + 24 (\frac{1}{2} (A + B) + C + D + E)]/T.$$

$$36 \text{ hours} = [R + 36 (\frac{1}{2} (A + B + C) + D + E)]/T.$$

$$48 \text{ hours} = [R + 48 (\frac{1}{2} (A + B + C + D) + E)]/T. —$$

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